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BEHAVIORAL ECONOMICS

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This special issue of the *Journal of the Experimental Analysis of Behavior* is devoted to behavioral economics—a relatively new yet expanding area of research and theory in the experimental analysis of behavior. Economics was first addressed in this journal (as indicated by the index) in an experimental report by Green and Rachlin in 1975. Since that report, behavioral economic articles have appeared with increasing frequency (see Figure 1), with the greatest number of articles published in the 3-year period from 1991 to 1993 (the last years covered by the index).

Many who read this journal may wonder what the appeal is of a discipline that is often cited for its inability to predict national trends accurately and that is frequently the target of jokes. (e.g., "If all the economists in the world were laid end to end, they wouldn't reach a conclusion. And if they did, it probably would be wrong.") Indeed, many might view this attraction to economics as a movement in a direction opposite to that of the current trends of embracing biological approaches, be they molecular approaches (the traditional provenance of the neurosciences) or evolutionary approaches (currently receiving increasing attention in the behavior-analytic field). Economics and biology, however, may not be as far apart as one might initially assume. Darwin, after all, was strongly influenced by the two Scottish economists, Thomas Malthus and Adam Smith, and the formal similarity between Smith's laissez-faire economy and Darwin's theory of natural selection has been noted by Gould (1993).

The appeal of economics for behavior analysis results not from its reputation (or lack thereof), nor from its relationship to biology. Rather, pragmatic considerations motivate its adoption: Economics provides a rich area of knowledge and conceptual elegance that offers new independent variables, methods of analysis, and dependent measures. New independent variables such as income and open and closed economies suggest a new view of choice and schedule performance; new methods of analysis such as unit price permit a parsimonious integration of multiple interacting variables and, importantly, specify mathematically how those variables interact; new measures such as elasticity (proportional change in consumption as a function of increasing price) and substitutability measure different features of reinforcers, ones that might be useful in comparing reinforcing events. These and other economic concepts and measurers also motivate alternative theoretical conceptualizations of how reinforcers influence behavior and compel the consideration of new applications and techniques for behavior change.

Having said this, however, we acknowledge that considerably more work will be necessary to identify the extent to which economics might further the behavior-analytic enterprise. Moreover, we recognize that the economic assertions that choices are rational and that they optimize utility are troubling to many in the field (as these assertions are to many in other fields as well). Concerns for rationality and utility maximization, however, are not part and parcel of every economic approach. One may embrace the use of economic concepts without also clinging to utility maximization. Economics is not a unitary enterprise. Its diversity, as is that of behavior analysis, can be gleaned from this special issue.

The articles that comprise this special issue congregate into three loose and overlapping themes: choice, demand-curve analysis, and the comparative analysis of behavioral economics.

Choice

No one area better represents the theoretical and empirical vitality of contemporary behavior analysis than does choice. Since Herrnstein's formulation of the matching law (1961, 1970), the spate of experimental reports and theoretical analyses has not abated.

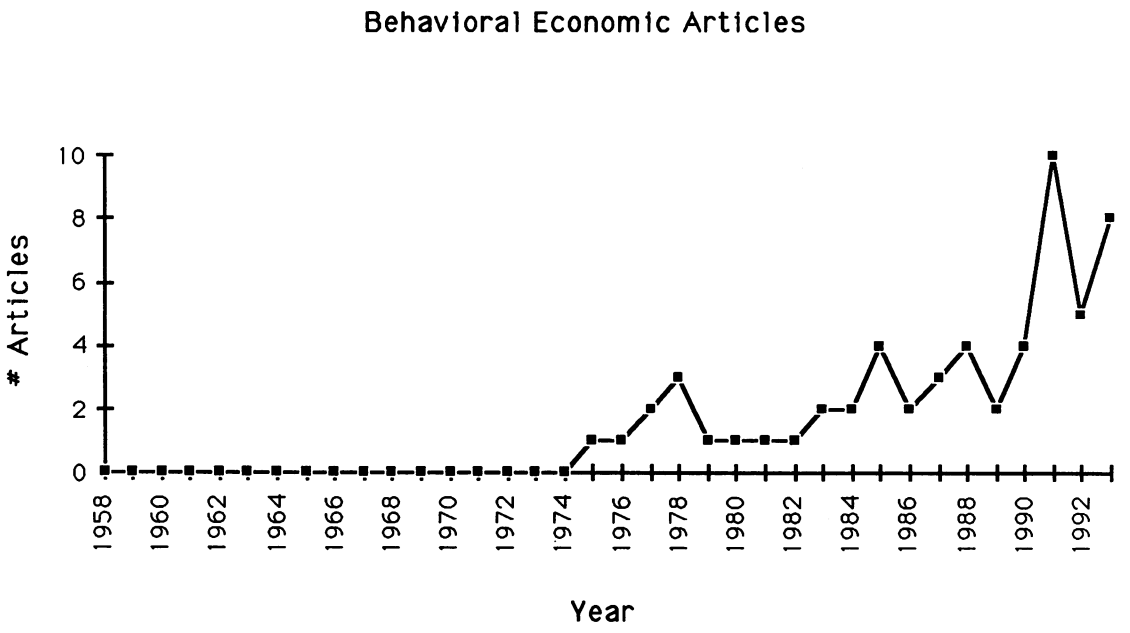

Fig. 1. The number of articles in *JEAB* per year that have used economic descriptors. Data collected from *JEAB* indexes.

It was the matching law that explicitly acknowledged the role of context in describing choice behavior. No longer could the effects of a reinforcer on a target response be studied in isolation; rather, the overall context within which the reinforcer occurs needs to be taken into account. Choice behavior is influenced by constraints (constraints of time, constraints created by schedules of reinforcement, etc.). With the realization of constraints and context came the initial foray into economics. After all, economics is the study of the allocation of behavior within a system of constraint. One could propose, therefore, that the study of economic factors such as price, income, and substitutability needed to be incorporated into the psychological models of choice. For example, microeconomic models, developed specifically to account for consumers' choices among different commodities as price and income vary, may inform psychological research in which schedule requirements are varied. So, too, if the distribution of behavior across response alternatives is related to the distribution of the reinforcers obtained from those alternatives, qualitative aspects of the reinforcers (i.e., their substitutability) may influence choice behavior just as quantitative aspects such as rate, magnitude, and delay do. Thus, economics may be a potentially powerful ally in our quest for understanding the processes underlying choice. As the articles in this special issue demonstrate, behavioral economics adds a dimension to our understanding of choice that could not have been possible prior to the interactive relation between economics and the experimental analysis of behavior.

Joel Myerson and Leonard Green report data from human subjects choosing between hypothetical amounts of money at various delays in order to study the formal relation between delay of reward and present value. Like earlier experiments that have used this preparation (e.g., Rachlin, Raineri, & Cross, 1991), Myerson and Green found that the value of delayed rewards is discounted according to a hyperbolic-like function rather than an exponential decay function. This consistent finding in the behavioral economic literature is important, given that microeconomic theory typically has relied on exponential functions. (Some general implications of nonexponential discounting are pursued in the paper by Howard Rachlin.) The Myerson and Green paper also makes several other important contributions to the

extensive literature on this issue. First, whereas earlier studies with humans had analyzed averaged data from groups of subjects, Myerson and Green fit equations to data from individual subjects. Second, results indicated that the discounting parameter varied inversely with amount of reward, and better fits to the data were obtained with the denominator of the discount function raised to a power. Third, their discussion of several different interpretations of the parameters of the discount function will facilitate future research aimed at identifying the mechanisms that control temporal discounting. Clarifying these mechanisms will have valuable implications for improving our understanding of important human behavior problems involving impulsiveness and self-control.

One issue that has divided supporters and attackers of behavioral economics relates to whether animals (including humans) maximize reinforcement. We will not go into the controversy here (the article by Rachlin discusses this issue) other than to note that for some, responses are distributed across alternatives so as to match the reinforcers obtained from the alternatives, whereas for others, responses are distributed across alternatives so as to maximize overall the reinforcers obtained. Gene Heyman and Lawrence Tanz describe a simple but novel procedure in which reinforcement was contingent on deviations from matching. Unlike previous research in which stimulus conditions were correlated with relative reinforcement rates, Heyman and Tanz incorporate discriminative stimuli that are correlated with changes in overall reinforcement rates. With this change in procedure, deviations away from matching and in accordance with maximizing could be shaped without apparent limit. The authors suggest that "maximization and matching are outcomes that depend on how the reinforcement contingencies are framed." Their conclusion is consistent with the view expressed by Rachlin, Green, and Tormey (1988) that "Matching and maximizing are not competing theories about the fundamental nature of choice, but compatible points of view that may reveal environmental function and behavioral structure" (p. 113, abstract). Heyman and Tanz have provided us with an exciting new procedure that can permit an investigation of both the structure and function and the processes that underlie matching and maximizing.

The paper by Case, Nichols, and Fantino illustrates another strength of the behavioral economic viewpoint, namely that it can be used to deal with issues in behavioral ecology. They varied the economic context, specifically the "budget" for the reinforcer, and examined its effects on risk-sensitive choice. Their finding that pigeons continue to prefer variable delays over fixed delays across a range of economic contexts helps to illustrate the robustness of that phenomenon. Their paper, then, is a fine illustration of how a behavioral economic perspective can lead to the identification of interesting and important independent variables.

Demand-Curve Analysis

Demand is the main dependent variable in microeconomics and simply refers to the amount of a commodity that is purchased (and presumably consumed). Behavioral economics shares this primary interest in consumption, and thus departs from the behavior-analytic tradition of focusing on responding as the main dependent variable. As noted by Hursh (1993), in behavioral economics "responding is regarded as a secondary dependent variable that is important because it is instrumental in controlling consumption" (p. 166). Concepts for the analysis of demand are derived from features of the demand curve, which in its basic form plots consumption of a reinforcer (or commodity) as a function of its price (see papers by Hursh & Winger, Petry & Heyman, and English, Rowlett, & Woolverton for examples). The basic parameters of demand curves are intensity and elasticity of demand, which are the height and slope of the curve (in log-log coordinates), respectively. Thus, intensity refers to the amount of consumption at a given point, and elasticity of demand refers to how consumption changes as price changes. Demand curves provide a convenient system of data representation in which the effects of a variety of variables can be quantified, such as type of reinforcer, availability of alternative reinforcers, and whether the economic context is open or closed (e.g., Hursh, 1984). The papers included in this

section further demonstrate the value of this type of representation of behavioral data.

R. Don Tustin applies the neoclassical theory of labor supply to operant schedule performance. His use of quadrant diagrams generates a way of measuring a subject's evaluation of reinforcers, and predicts performance with single schedules of reinforcement as well as with concurrent schedules. In addition, his model makes important, testable predictions, ones that will be of utmost interest to both experimental and applied behavior analysts. For example, his behavioral economic model predicts that, under specified circumstances, preference between reinforcers will not remain constant as total reinforcement increases. Preference between reinforcers, in fact, may reverse, a prediction unique to the theory.

A fundamental idea in behavioral economics is that demand for any commodity depends on the economic context in which it is available. In applications of behavioral economics to substance abuse (e.g., Green & Kagel, in press), this basic idea immediately raises the issue of identifying the conditions under which consumption of the abused substance emerges from a context of nondrug reinforcers as a highly preferred activity (e.g., Vuchinich & Tucker, 1988). This issue is addressed by Nancy Petry and Gene Heyman in several experiments with rats in a choice situation involving access to sucrose and an ethanol-sucrose mixture. By systematically altering the response requirement (price) across experiments, they showed an asymmetrical substitution relation between, and differences in the elasticity of demand for, the drug and nondrug reinforcers. That is, when the price of ethanol-sucrose was increased and the price of sucrose was held constant, ethanol consumption tended to be maintained and the consumption of sucrose did not change. On the other hand, when the price of sucrose was increased and the price of ethanol-sucrose was held constant, sucrose consumption decreased rapidly and ethanol consumption increased. If such relations between the demand for drug and nondrug reinforcers prove to have any generality, important advances may be made in understanding the development and maintenance of substance abuse.

Justin English, James Rowlett, and William Woolverton report reanalyzed data from an experiment by Hoffmeister (1979) in order to explore the generality of the relationship between unit price and demand for drugs. Numerous experiments have found that drug self-administration is affected by response requirement and drug dose, and behavioral economics has contributed to this literature by proposing that these two manipulations can be combined into one independent variable, termed *unit price,* by forming the ratio of response requirement to drug dose (e.g., Bickel, DeGrandpre, & Higgins, 1993). Prior reports (e.g., Bickel, DeGrandpre, Higgins, & Hughes, 1990; DeGrandpre, Bickel, Hughes, & Higgins, 1992) have found that demand for drugs is a positively decelerating function of unit price, indicating that elasticity of demand increases with unit price and suggesting that manipulations of response requirement and drug dose are functionally equivalent. In the Hoffmeister study, monkeys received infusions of four different opioids in a broad range of doses according to progressive-ratio schedules of reinforcement. English et al.'s reanalysis of these data in terms of unit price showed some differences from earlier reports; the demand curves were more linear than positively decelerating, and drug dose had stronger effects on demand than did response requirement. These results emphasize the complexity of the variables that control drug self-administration and suggest future experiments that will further delineate the relation between the economic context and demand for drugs.

Steven Hursh and Gail Winger take on an emerging issue in their application of demand-curve analysis to the study of drugs of abuse. Most drugs of abuse function as reinforcers and can be studied in the animal and human laboratory. One important issue is discerning whether one drug reinforcer might have a greater potential for abuse than another drug reinforcer. Hursh and Winger suggest that demand (consumption) curves may permit such an analysis. A problem posed by this analysis is that the quantity of a drug taken at low prices may vary widely as a function of the potency of the drug (e.g., some drugs are administered by weight in microgram units, whereas others are administered in milligram units). These potency dif-

ferences pose a problem in making comparisons. Hursh and Winger suggest that this difficulty may be overcome by normalizing their potency. The approach appears to be promising from the data presented in their paper and may add significantly to the ability of basic laboratory research to address issues of societal relevance.

Relation of Behavioral Economics to Other Approaches

Central to evaluating behavioral economics and its potential contributions to the experimental and applied analysis of behavior is understanding points of commonalities with and points of departures from other behavioral perspectives. By discerning commonalities, one identifies those elements of the different approaches that are noncontroversial and the range of phenomena in which the data are relatively unambiguous. By discerning points of departure, one identifies those aspects that are controversial. These areas of controversy may, in turn, occasion new experiments that may clarify the disagreements and produce theoretical insights that advance our understanding and suggest new applications. The paper by Tustin, described earlier, stands as an exemplar of this. Also, this special issue contains three other papers that directly explore the relation of behavioral economics to other approaches.

John Nevin provides a welcome analysis and comparison of demand elasticity and behavioral momentum. Nevin points out the fundamentally different conceptions of the reinforcement process entailed by the two approaches. Specifically, "The behavioral momentum approach affirms the traditional Skinnerian position that consequences select and strengthen the operant class on which they are contingent." The behavioral economic approach, on the other hand, stresses that under a contingency constraint, instrumental and contingent behavior are reallocated in such a way as to maximize overall utility or minimize deviations from a set point. In spite of such "radically different conceptions of behavior and its consequences," the substantial overlap between behavioral economic and behavioral momentum approaches is striking. He demonstrates how "both can accommodate a variety of data collected within the framework of either approach." In addition, he points out areas in which one approach suggests limitations on the other and proposes experimental tests to evaluate competing explanations.

As noted, the maximization of utility and rationality aspects of microeconomic theory and their incorporation into behavioral economics have troubled many behavioral scientists (e.g., Herrnstein, 1990). A major and obvious source of this concern is that the literature is replete with apparent instances of irrational and submaximal behavior. Howard Rachlin points out that the ubiquity of such findings has led behavioral economics to be viewed as the study of anomalies, with an anomalous finding being defined by virtue of its deviation from rationality. But this definition of anomalies depends on the definition of rationality, and Rachlin argues for a redefinition of rationality so that the so-called anomalies disappear. Rachlin's paper challenges some fundamental concepts of both economics and behavior analysis, but it remains faithful to Skinner's dictum that "the subject is always right" and it places behavioral economics in a better position to identify functional relations between behavior and the environment.

The final paper of the special issue is by Peter Killeen. In comparing economics, ecologics, and mechanics, Killeen notes that as a science of final causes, economics is concerned with the goals around which behavior is organized. But as important as the understanding and identification of the final causes of behavior are, Killeen forcefully argues that a mechanics—a "science of formal causes"—is equally if not more important. By a mechanics of behavior Killeen does not mean to suggest outdated models entailing gears and pulleys, but rather one that focuses on mathematical linkages between cause and effect. Indeed, his mechanics impressively accounts for a number of phenomena, many of which are otherwise difficult to understand or explain. The mathematical models are extended to deal with deprivation, satiation, and arousal. The models account for within-session changes in responding and results from open and closed economies. The mathematical formalization of changes in deprivation (depletion and repletion rates) is what distinguishes the mechanics of behavior as an explanation from an economic account in

which changes in elasticity are posited. Killeen serves up an impressive theoretical contribution, one that provides an alternative yet complementary model of behavior.

Conclusion

This special issue was prepared because we believe that behavior analysis benefits from the inclusion of behavioral economics. The overarching goal is to offer the reader a selection of research and theory motivated by a behavioral economic framework. Within that larger goal, we hoped that (a) some of the articles would present empirical studies in which behavioral economics was at the core of the research in order to demonstrate its appeal and (dare we say) its utility for the experimental analysis of behavior; (b) theoretical papers predicated on behavioral economics would demonstrate its value for the further development of theory; and (c) critical discussion would be offered in order to extend the dialogue and increase interaction with researchers who may be less familiar with behavioral economics. We are pleased that from our perspective the papers in this special issue fulfill these goals. Of course, it is up to the reader to evaluate for him or herself how well and to what extent the goals have been met.

Finally, we return to an issue raised earlier in this essay. Although we may talk about "behavioral economics" as if there were this singular enterprise, we remind the reader that those who conduct research under the rubric of behavioral economics are not all cut from the same cloth. For some, elasticity of demand plays a major organizing role; for others, substitutability is the concept most valuable in understanding and describing choice. For some, economic concepts provide a rich conceptual framework; for others, the theory is of little relevance—it is the methods of analysis that are useful. For some, maximization of utility is assumed; for others, no such assumption is made. The success of behavioral economics will depend on its ability to describe and predict behavior under changing constraints, to offer new interpretations, and to suggest new insights and applications. Although we believe that behavioral economics has already achieved some measure of success, our hope is that this special issue will spur continued development.

REFERENCES

Bickel, W. K., DeGrandpre, R. J., & Higgins, S. T. (1993). Behavioral economics: A novel experimental approach to the study of drug dependence. *Drug and Alcohol Dependence, 33,* 173–192.

Bickel, W. K., DeGrandpre, R. J., Higgins, S. T., & Hughes, J. R. (1990). Behavioral economics. I. Functional equivalence of response requirement and drug dose. *Life Sciences, 47,* 1501–1510.

DeGrandpre, R. J., Bickel, W. K., Hughes, J. R., & Higgins, S. T. (1992). Behavioral economics of drug self-administration: III. A reanalysis of the nicotine regulation hypothesis. *Psychopharmacology, 108,* 1–10.

Gould, S. J. (1993). *Eight little piggies.* New York: W. W. Norton.

Green, L., & Kagel, J. H. (in press). *Advances in behavioral economics: Vol. 3. Substance use and abuse.* Norwood, NJ: Ablex.

Green, L., & Rachlin, H. (1975). Economic and biological influences on a pigeon's keypeck. *Journal of the Experimental Analysis of Behavior, 23,* 55–62.

Herrnstein, R. J. (1961). Relative and absolute strength of response as a function of frequency of reinforcement. *Journal of the Experimental Analysis of Behavior, 4,* 267–272.

Herrnstein, R. J. (1970). On the law of effect. *Journal of the Experimental Analysis of Behavior, 13,* 243–266.

Herrnstein, R. J. (1990). Rational choice theory: Necessary but not sufficient. *American Psychologist, 45,* 356–367.

Hoffmeister, F. (1979). Progressive-ratio performance in the rhesus monkey maintained by opiate infusions. *Psychopharmacology, 62,* 181–186.

Hursh, S. R. (1984). Behavioral economics. *Journal of the Experimental Analysis of Behavior, 42,* 435–452.

Hursh, S. R. (1993). Behavioral economics of drug self-administration: An introduction. *Drug and Alcohol Dependence, 33,* 165–172.

Rachlin, H., Green, L., & Tormey, B. (1988). Is there a decisive test between matching and maximizing? *Journal of the Experimental Analysis of Behavior, 50,* 113–123.

Rachlin, H., Raineri, A., & Cross, D. (1991). Subjective probability and delay. *Journal of the Experimental Analysis of Behavior, 55,* 233–244.

Vuchinich, R. E., & Tucker, J. A. (1988). Contributions from behavioral theories of choice to an analysis of alcohol abuse. *Journal of Abnormal Psychology, 97,* 181–195.